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STRUCTURE AND BEHAVIOR OF THE AMPHIPOD, POLYCHERIA OSBORNI

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When compared with the social insects, most crustacea undoubtedly have a very simple ecology. However, in many cases the great simplicity may be apparent only and due to our lack of detailed information. It should be remembered that, to a very large extent, this field of inquiry is still a virgin one, and future investigations probably will reveal much complexity of habits and behavior where simplicity is anticipated. Indeed, some crustacea are known to have ecological features of great interest. Especially among the amphipods, many examples of unique behavior and adaptation are to be found.

In the present paper an account will be given of some of the habits of a marine amphipod occurring in a compound ascidian on the west coast of North America. It has been judged advisable to include also a description of the external morphology of this species, since this is very incompletely known.

The genus *Polycheria,* which was established by Haswell (1879, Proc. Linn. Soc. N. S. Wales, vol. 4), belongs, together with

four other genera, to the family Dexaminidæ Leach. None of these five genera has been submitted to a careful morphological analysis, and so our knowledge of what constitutes the generic characteristics in this family is still very unsatisfactory. A result of this is that many of the characteristics included in the description given below are not specific but of a higher systematic value, later on to be transferred to the description of the genus, or, in some cases, perhaps even to that of the family.

Polycheria osborni Calman

Polycheria osborni Calman, 1898, p. 268, pl. 32, fig. 2.

Description: Female: Maximum length in the natural, somewhat curled position, exclusive of antennæ, somewhat more than 4 mm.; when straight, inclusive of telson, somewhat less than 6 mm. Without stating how the measurements were made, Calman (p. 269) records the length of 7 mm. Shape of body in lateral view, about as in Calman's figure 2; only the body proper is sometimes slightly deeper, relatively. Rostrum (fig. 24) very small, slightly bent down. Lateral eyes slightly smaller than in Calman's figure. Body grayish pink or slightly variegated in living individuals; eyes red to violet, when seen at certain angles with a white reflection. Ventral side of thorax with fine, white spots often arranged in two cross-bands, sometimes irregularly arranged. When preserved, the specimens are whitish, with dark eyes.

First antenna (fig. 2): Somewhat more than 0.5 length of body. With 23 joints; of these the 21 distal are subequal and taper gently distally; second joint, 5-6 times longer than wide, gently tapering distally, about 0.3 the total length of joints 3-23; first joint somewhat shorter than second and about twice longer than wide; first joint with 1-3 short hairs on dorsal side and 3-6 on ventral; second joint with about 3-5 short hairs along dorsal margin; ventral margin with spaced, fairly long to short hairs, often arranged in groups of 2-4; third joint with a varying number (about 5-10) of distal bristles, about as long as joint or somewhat longer or shorter; each of joints 4-14, inclusive, with a ventro-distal group of four bristles, one of which is sensory and about as long as

joints; one somewhat shorter than the sensory; and two about as long as total length of 3-4 of these joints on joints 10-14, inclusive, somewhat shorter on preceding joints. On joints 15-22, inclusive, a similar ventro-distal group of bristles occurs but without sensory bristle; the long bristles of these joints decrease slightly in length the more distally they are located. Distal (23rd) joint with five distal bristles, two of which are short, three about as long as the long bristles on the preceding joint. Joints 5, 7, 9, 11, 13, 15, 17, and 19 usually have two short dorso-distal hairs. On some of these joints only one of these hairs may be present; and a short hair may occur on one or two of the joints usually lacking these structures. Joints 21 and 22 have one and two, respectively, of these short, dorso-distal hairs. All bristles of this antenna are simple, i. e., not plumose.

Second antenna (fig. 5): About as long as first antenna and composed of 20-22 joints. Of these the three proximal are short, about as long as wide or even shorter; the fourth is 0.20-0.25 the length of the appendage, about five times longer than wide, gently tapering distally; the fifth somewhat shorter than fourth, subuniform in width throughout, and about eight times longer than wide; the remaining 15-17 joints are subequal in length, or some of the proximal are somewhat shorter than the distal. The first two joints lack bristles and hairs. The third joint has 5-7 bristles; 4-6 of these are ventral and about as long as or somewhat shorter than joint; dorsally there are one bristle, about as long as joint, and a few short hairs. Fourth joint with a varying number (frequently quite numerous) of rather short hairs along dorsal side; and with a few (about 4-7) short hairs along ventral side. Fifth joint with a varying number of short to moderately long hairs along dorsal side; along ventral side it has about 4-6 moderately short to rather long (somewhat more than 0.5 the length of joint) bristles and a few short hairs. With the exception of the distal joint, the remaining joints usually have a ventro-distal group of four bristles of about the same relative length as the corresponding bristles of the first antenna; in some specimens one or both of the short bristles may be absent in a few of these groups; and an extra bristle may appear on one or a few of the proxi-

mal of these joints. Distal joint with the same equipment of bristles as in the first antenna, but with four instead of three long bristles. Structure of bristles the same as in first antenna, with the exception that no bristles are specialized sensory structures.

Labrum: Broadly attached, almost circular in ventral outline, vaulted dorsally, concave ventrally, its distal third pubescent.

Labium (fig. 3): Consists of two well developed pairs of lobes, of which the ventral is about twice as large as the dorsal, the two members of ventral pair widely separated distally, ovate, with outer edges more convex than inner and notched about ⅔ distally; distal third pubescent. Members of dorsal pair closely approximated, ovate, with nearly straight inner edges, thin, hyaline, and naked.

Right mandible (fig. 8): The outer margin forms nearly an arc of a circle; without structural differentiations. Inner margin somewhat concave; furnished proximally with a large masticatory plate, distally to which some bristles and a movable tooth occur. Distal end of appendage forms a powerful, immovable tooth. Masticatory plate nearly as wide as long, obliquely subtruncate distally; near base of its inner margin there is a low, angular protuberance; its distal edge with numerous (about 30-50) small, subequal teeth; on outer margin a plumose bristle, about as long as process is wide or somewhat shorter. Bristles distally to masticatory plate subequal to and of the same structure as bristle of masticatory plate; their number usually two, but sometimes only one of them is present. Movable tooth powerful, about as long as masticatory plate is wide, deeply bifurcate; its two prongs gently curved, more or less unequal in size, the outer one the smaller; a few small, secondary teeth may be present. Distal tooth subequal to but more powerful than movable tooth; with 4-6 powerful secondary teeth of which the distal often is the largest. Along toothed edge of masticatory plate and at base of bristles fairly short to moderately long hairs occur.

Left mandible (fig. 6): This differs in the following respects from the right: bristles distally to masticatory plate number 2 or 3; the two prongs of movable tooth furnished,

respectively, with 2 and 3-4 fairly strong, subequal, distal teeth.

First maxilla (fig. 18): First endite of moderate size, about as long as wide, rounded distally. With two bristles, one distally, the other on inner margin frequently near distal end; distal bristle subequal in length to endite; the other slightly longer to 0.5 this length; both bristles with fine tips and with long, soft secondary bristles near middle and short ones distally. Distal half of endite with fine, short hairs. Second endite subrectangular, 1.5 – 2.0 times longer than the first, its truncate distal edge with 7 powerful bristles; these are often subequal in length and about as long as endite or a little less, usually denticulate in the middle, and with strong tips. Palp one-jointed and reaches to or slightly beyond tip of second endite; subuniform in width to near distal end which tapers abruptly; about three times longer than wide; with 5 (seldom 6) bristles at and near tip; bristles of slightly different lengths, the longest subequal to length of palp; structurally they agree with bristles of first endite. Fine, short hairs occur along inner and distal margins of palp.

Second maxilla (fig. 19): Both lobes well developed, the inner about ⅓ shorter than the outer. Inner lobe about three times longer than wide, rounded distally, its inner distal margin with 6 (4-7) bristles of somewhat variable length; variations irregular, but usually no bristle is longer than the longest in figure nor shorter than 0.5 this length; short, fine hairs along inner and distal margins of lobe. Outer lobe three times longer than wide, slightly widened distally to middle, rounded distally; distal margin with 10 (9-11) bristles, subequal in length to those of inner lobe; short, fine hairs along inner and distal margins of lobe. All bristles of this appendage agree structurally with those on first endite of first maxilla.

Maxilliped (figs. 1, 12): First endite about 0.50 as long as second endite, slightly longer than the greatest width of the latter, 2-3 times longer than wide, and rounded distally; near distal end with 4-6 moderately strong bristles about 0.33 the length of endite. Second joint of protopodite about 0.5 as long as wide; with about 4 subequal, distal bristles on inner edge similar to those of palp. Second endite large, nearly subequal in length to palp, about 2.5 times

longer than wide, scythe-like, with inner margin nearly straight; along distal ⅔ of inner margin with 10-14 spines, the 1-2 distal ones of which usually are somewhat larger than the others, which vary considerably in size; maximum length of spines about 0.33 the width of endite; between all spines there is a thin, hyaline, subtriangular structure of somewhat variable shape; proximal ⅓ of inner edge of endite with fine pubescence. Palpus: First and third joints subequal in length, somewhat shorter than first endite; third joint broader distally than proximally, rounded subtriangular, frequently even more so than in figure 12. Second joint somewhat wider than remaining joints, about 0.75 – 0.80 as wide as second endite, with strongly convex inner margin, and about 1.5 times longer than first joint. Fourth joint subconical, often with angular outer edge, its length usually subequal to 0.5 the width of third joint. First joint with 4-7 bristles near distal end. Second joint usually with three subparallel, oblique rows of bristles on inner ventral side; of these rows, the two proximal sometimes very irregular; each of the two proximal rows with about 6-8 bristles; distal row with 9-12; 2 or 3 bristles may be found ventrally on lateral side of joint. Third joint with about 20 bristles distally, half of which are ventral, half dorsal; on ventral side 2-5 bristles occur near middle of joint and 3-7 on distal end of joint near outer margin. Most bristles of these three joints subequal, nearly as long as second joint is wide, and all of them resemble structurally the bristles on the palp of the first maxilla. Fourth (distal) joint with a single bristle near, or somewhat proximally to, middle of outer side, about as long as joint or somewhat shorter; a short, powerful spine at tip of joint, near which three weak, subequal bristles occur, about as long as or slightly shorter than spine.

First gnathopod (figs. 7, 22): First joint short, about as long as wide or somewhat shorter; with anterior, narrowly mammilliform endite about as long as joint or somewhat shorter. Second joint long, somewhat shorter than total length of next four joints, about 4 to 5 times longer than wide. Third joint about as long as wide or slightly shorter. Next three joints about 1.5 times longer than wide, the fifth being slightly larger than the fourth and sixth; the fourth and sixth somewhat wider distally than proximally, the fifth

vice versa. Seventh joint somewhat curved, claw like, usually somewhat shorter than width of sixth. Endite of first joint with 2-4 bristles, usually shorter than endite; 2 small bristles are often found anteriorly near base of joint; and a couple of short ones may occur distally on inner side of joint. Second joint with 2 postero-distal bristles, about 0.5 as long as width of joint or somewhat shorter; along anterior side about 5-11 fairly short bristles occur; and near middle of this side, there are 4-8 bristles about as long as joint is wide or somewhat longer or shorter. Third joint with 3-6 postero-distal bristles of unequal lengths, the longest about as long as joint; a short bristle is often found on inner side of joint near anterior margin. Fourth joint with a varying number (about 25-45) of bristles of different lengths, most of them concentrated along distal half of posterior margin; greatest length of these bristles usually subequal to length of joint. Fifth joint with about 15-22 bristles along posterior margin; besides, there are about 6-15 scattered bristles, most of which occur on inside of joint; maximum length of these bristles subequal to width of joint. Sixth joint, like the preceding one, has but few scattered bristles on outer side. On inner side a large number of bristles of different lengths occur, usually arranged in about the following manner (fig. 7): near anterior edge 5-8 oblique cross rows, with a maximum number of about 9 in each row, and usually with a smaller number in the proximal rows than in the distal; towards the posterior edge, there are three or four obliquely longitudinal rows, two of which may form a single row; largest number of bristles in each row about 7; sometimes the rows are not quite distinct; besides these bristles, a few scattered ones always occur. Maximum length of bristles of this joint subequal to length of joint. Palmar edge of this joint about 0.33 the length of seventh joint, hyaline, furnished with numerous, closely set, minute spines. Seventh joint with a short bristle proximally to middle of anterior side, about 0.25 – 0.33 the length of joint; near tip of joint, 4 short points occur; entire surface of joint with closely set, minute spines. Nearly all the bristles of this appendage with fine pectination along distal half; a few may have rather long, fine secondary bristles near middle.

Second gnathopod (figs. 4, 9): Of about the same size as the first, from which it differs in shape only in the following respects: first joint about twice longer than wide, with somewhat shorter, triangular endite; fifth joint wider distally than proximally; sixth joint about twice longer than wide or somewhat more and but slightly wider distally than proximally. Endite of first joint with 1-4 bristles, the longest about as long as endite; a very short bristle is often found anteriorly near base of joint and another short one near base of endite. Along anterior side of second joint about 5-10 bristles; most of these are short, one to a few moderately long (maximum length subequal to width of joint). Postero-distally this joint has 2-5 bristles of different lengths, the longest sometimes somewhat longer than width of joint; along posterior side this joint has 5-11 bristles of varying length, the longest about as long as joint is wide. Third joint postero-distally with 1-3 bristles, the longest of which is about as long as joint. Fourth joint with about 14-25 bristles of different lengths, most of which are concentrated along distal half of posterior margin; greatest length of these bristles about twice the length of the joint or slightly more. Fifth joint with about 15-40 bristles of different lengths, most of which are concentrated postero-distally, where some of them form two longitudinal rows along edge of joint; maximum length of these bristles slightly exceeds length of joint. Sixth joint (fig. 9) has bristles arranged in about the same manner as in the first gnathopod, but there are only 4-5 cross rows of bristles on inner side near anterior margin, and the number of bristles is somewhat less; maximum length of bristles somewhat less than length of joint. Hyaline plate of the palmar edge of this joint somewhat lower and longer than in first gnathopod, being about 0.5 the length of the seventh joint; its structure the same as in the preceding appendage. Seventh joint and structure of bristles about the same as in the preceding appendage, only the seventh joint is slightly shorter.

First pereiopod (figs. 10, 23): First joint slightly shorter than wide, with narrow, mammilliform process about as long

as joint or slightly shorter. Second joint about 0.30 the length of leg and about 2.5 times longer than wide. Third joint somewhat shorter than wide. Fourth joint slightly shorter than second and about three times longer than wide. Total length of fifth and sixth joints subequal to length of second joint, the fifth being somewhat shorter than the sixth; the sixth about 3.5 – 4.5 as long as wide. Distal joint curved, claw like, nearly as long as preceding joint is wide. Process of first joint with 2-4 bristles, the longest subequal to or somewhat shorter than process; opposite to process, this joint has about 3-6 bristles of different lengths, the longest about as long as process. Second joint has 4-8 bristles along anterior side, 3-5 along posterior side, and 2-4 postero-distally; third joint with 2 or 3 postero-distally; fourth joint with 3-6 along anterior side, 2-3 antero-distally, 3-6 along posterior side, and 3-4 postero-distally; fifth joint with about 3 antero-distally, 1 at the middle of posterior side, about 2-3 postero-distally, and frequently 1-2 distally on outer side; sixth joint with a group of about 1-3 anteriorly and somewhat proximally to tip, 1 or 2 somewhat proximally to these, 5-11 antero-distally, 2-3 along posterior side, 1 on inside of base of postero-distal finger like process, 3 at tip of finger, and 1 near base of distal joint; distal joint with 1 somewhat proximally to middle of anterior side, and 1 posteriorly a short distance from tip. Most bristles of second to fifth joints usually quite short, and many of them (proportion variable) are sensory spines of type shown in figure 21; maximum length of these bristles usually does not exceed width of joints, and most bristles are decidedly shorter. Sixth joint: bristles in group somewhat proximally to distal end of anterior side and those proxmally to these are rather short and strong; antero-distal bristles of different lengths, the longest frequently somewhat longer than width of joint, and none of them is spine like; bristle at base of finger-like process is about as long as joint is wide or even somewhat longer, and usually somewhat longer than the other bristles on the posterior side of joint; bristle near base of distal joint rather short and spine-like, just as bristles at tip of finger. Anterior bristle of distal joint

fine and about 0.5 as long as joint or somewhat more; posterior one nearly vestigial.

Second pereiopod: First joint differs from corresponding joint of first pereiopod mainly in having a shorter and blunter process; frequently the process is even rounded subrectangular. Proportions of remaining joints about the same as in the mentioned leg. Second joint with 3-10 bristles along anterior side, 2-7 along posterior side, and 2-3 postero-distally; third joint with 1-3 postero-distally; fourth joint with 2-6 along anterior side, 2-3 antero-distally, 3-6 along posterior side, and 2-4 postero-distally; fifth joint with 2-3 antero-distally, usually with 1 near middle of posterior side, 2-4 postero-distally, and frequently 2 distally on outer side; sixth and seventh joints with the same number and arrangement of bristles as in the preceding leg. Types and relative lengths of bristles about the same as in the preceding leg.

Third pereiopod (fig. 20): Of about the same size as the two preceding legs, but the second joint is slightly larger relatively, and the fifth joint is about 2.5 times longer than wide and somewhat larger than the sixth which also is about 2.5 times longer than wide. The first joint may lack bristles, or it may have 1-3 on anterior side and 1-3 posteriorly; second joint with 3-8 bristles along anterior side and 3-7 along posterior side; third joint with 1-2 antero-distally; fourth joint with 3-7 along anterior side and 2-6 along posterior side; fifth joint with 2-6 along anterior side and 2-5 along posterior side; sixth joint with 1-3 anteriorly and somewhat proximally to distal end, 4-6 antero-distally, 1-4 along posterior side; distal joint with 1 bristle anteriorly and somewhat distally to the base and 1 posteriorly and somewhat proximally to tip. The bristles of this leg differ from those of the preceding leg mainly in the following respects: they are somewhat fewer and slightly weaker, at least in some specimens; in some specimens but a few of them are sensory spines, while in others the proportion of these spines is about the same as in the preceding leg; the third joint has the bristles antero-distally instead of postero-distally; the antero-distal bristles of the sixth joint are somewhat shorter, and there is no bristle at

the base of the finger like projection of this joint; the spine of this joint near base of distal joint is either vestigial or absent.

Fourth pereiopod: Of about the same size as the preceding leg, but the second and fourth joints are subequal in length; of the fifth and sixth joints, the total length of which is somewhat less than the length of fourth joint, the sixth is slightly the longer; the sixth joint is about twice longer than wide, the fifth somewhat less. First joint with 2 or 3 bristles anteriorly and about 1 posteriorly; second joint with 4-7 bristles along anterior side, 2-3 antero-distally, 4-9 along posterior side, and 2-3 postero-distally; third joint with 2 or 3 antero-distally; fourth joint with 4-9 along anterior side, 2-3 antero-distally, 4-6 along posterior side, and 2-4 postero-distally; fifth joint with 1-2 along anterior side, 2-3 antero-distally, 1 near middle of posterior side, 2-3 postero-distally, and frequently with 2 distally on outside of joint; sixth joint with about the same number and arrangement of bristles as in the first pereiopod; seventh joint with 2 bristles of the same type, size, and location as in the first pereiopod. The bristles of this leg differ from those of the first pereiopod mainly in being somewhat longer and more powerful on the average; and one of those in the antero-distal group of the sixth joint is a spine which is not the case in any of the three preceding legs.

Fifth pereiopod (fig. 25): First joint with subtriangular process about as long as or somewhat shorter than corresponding process of first pereiopod; fourth, fifth, and sixth joints either of about the same strength as in the preceding leg or somewhat heavier and wider; of the fifth and sixth joints, the total length of which is subequal to length of fourth joint, the sixth is slightly the longer; the sixth joint is about twice longer than wide, the fifth somewhat less. First joint with 1-2 bristles on process, and usually none anteriorly, second joint with 4-8 bristles along anterior side, 1-3 antero-distally, 6-14 along posterior side, and 1-3 postero-distally; third joint with 2-3 antero-distally; fourth joint with 3-9 along anterior side, 2-5 antero-distally, 2-5 along posterior side, and 2-5 postero-distally; fifth joint usually with 1 near middle of anterior as well as of posterior side, about 2-3 antero-distally as

well as postero-distally, and frequently 2 distally on outside of joint; sixth joint with about the same number and arrangement of bristles as in the first pereiopod; seventh joint with 2 bristles of the same size, structure, and location as in the first pereiopod. The bristles of this leg have about the same lengths and types as in the fourth pereiopod (those in figure 25 are, on the average, somewhat shorter than usual).

Marsupial plates (fig. 11): A pair of these occurs on each of the following four appendages: second gnathopod, first, second, and third pereiopods. All of them are about similar in shape; slender, about eight or nine times longer than wide, subuniform in width throughout, rounded distally, and somewhat notched at places where bristles are inserted. The ones on the first and second pereiopods are subequal, slightly longer than the ones on the second gnathopods, and 0.33 longer than the ones on the third pereiopods. The first pair has about 22-30 bristles on each member; the second and third, 23-35; the fourth, 14-26; posterior side, one the average, with a somewhat smaller number of bristles than the anterior. All bristles naked; most of them about half as long as plates or somewhat shorter or longer, the proximal being, on the average, somewhat shorter than the others.

Gills (fig. 11): Six pairs; one pair on second gnathopods and one on each of the five pairs of pereiopods. About two to three times longer than wide, more or less narrowly subobovate to subovate, flattened on one side in the case of the three anterior ones, nearly symmetrical in the case of the two posterior. The three anterior subequal in length to second joints of corresponding appendages; the fourth about half as long as this joint or somewhat more; the fifth somewhat smaller.

Pleopods (fig. 13): The three pairs about similar in shape; biramous, with exopodite and endopodite many-jointed and subequal in size. Protopodite rectangular, somewhat longer than wide, with about 6-12 bristles, some of which are near distal end, some more proximally; most of these bristles fine and about half as long as joint is wide; two, situated near distal end of inner margin, are short, rather strong, and furnished with 2-3 pairs of retroverted teeth. Exopodite with 12-16, endopodite with 9-15 joints; it

should be emphasized, however, that the proximal joints are very indistinct, hard to detect, and that sometimes traces of joints can be found down to the bases of the two branches. Each distinct joint has on either side a densely plumose distal bristle; those on distal joints somewhat more than half as long as branches, the proximal ones shorter. Proximally to the distinct joints a few bristles may be found, usually much shorter than the distal.

First uropod (fig. 16): The process from which this appendage issues has 4-10 fine, lateral bristles which are about as long as first joint of appendage is wide and furnished with moderately long, fine hairs. First joint (protopodite) of appendage about 2.5 times longer than its average width, slightly tapering distally; along outer edge it has 10-18 bristles of the same type as and either about as long as or somewhat longer than bristles proximally to appendage; ventroproximally 2-3 similar bristles occur; on dorsal side, there are two longitudinal rows of rather short spines, the inner row near or on inner margin of joint; there are 2-6 spines in outer row, 4-9 in inner. Exopodite about as long as first joint. endopodite subequal in length to exopodite or usually slightly shorter; both are similar in shape, gently tapering distally, about 7-8 times longer than wide. Exopodite with 3-8 rather short spines along outside, 1-5 along inside; endopodite with 2-9 along outside and with 1-4 somewhat longer ones along inside; average length of short spines about half the width of branches, the long ones about twice longer. Distally the exopodite has two spines, one about as long as branch is wide or somewhat shorter, the other about 0.25—0.33 the length of branch. Endopodite with only one distal spine, subequal to the long distal one of exopodite. On either side of distal spines of exopodite and endopodite, the chitinous wall forms a short, strong spine. Long, distal spines lack sensory hair; the same is frequently also true in regard to the long spines on inner edge of endopodite. Most of the remaining spines appear usually to have a sensory hair, although this frequently is very difficult to detect; in other words, most of them have about the same structure as the bristle represented in figure 21. Edges of exopodite and endopodite with dense, exceedingly short hair.

Second uropod (fig. 15): Somewhat smaller than the first, but difference in size somewhat variable; relative size frequently as in figures 15 and 16. Protopodite about 2-3 times longer than wide, of subuniform width throughout; frequently with a longitudinal row of about 3 short spine on dorsal side, but these spines may be absent; distally on inner margin may be found 1-3 fine bristles of about the same type and length as the bristles on the outside of the protopodite of the first uropod. Exopodite about 1.3 – 1.5 times longer than protopodite; endopodite somewhat shorter; both 7-8 times longer than wide and taper distally. Exopodite with 1-4 spines along outside, 0-3 along inside, and 2 distally; endopodite with 1-5 along outside, 2-4 along inside, and 1 distally. Relative length and structure of spines about as in the first uropod; and chitinous walls of exopodite and endopodite form short, strong spines distally, just as in the first uropod. Hairiness as in first uropods.

Third uropod (fig. 14): Somewhat smaller to slightly larger than first. Process on which this appendage is inserted with a short spine near inner edge. First joint about as long as wide or frequently somewhat longer; in most specimens with a dorsal, longitudinal row of 3-5 short spines, frequently fairly near to outer edge, and with 1-3 short bristles or spines near inner edge. Exopodite 1.5 – 2.0 times longer than protopodite, about 5-6 times longer than wide, tapering distally; endopodite of about the same shape and width as but 1.5 times longer than exopodite. Exopodite with 0-5 (usually 3-5) short spines along outside, 4-7 along inside and a short hair near tip. Endopodite with 4-7 short spines along outside, 3-9 along inside, and a short hair near tip. Sometimes this branch has 1-14 fine bristles of varying length along inner and outer edges, and such bristles may also be found on exopodite. Structure of spines and hairiness as in first uropod.

Telson (fig. 17): Elongate, about twice longer than wide, tapering distally, split longitudinally in the middle nearly to base, the two members close together and pointed distally. Outer edge of each member usually with 5 spines, but occasionally only 3 or 4 are developed; these spines have about the same size and structure as the short spines of the uropods,

the distal being slightly longer than the proximal. Short, fine hair, such as found along the edges of the uropods, appears usually to be absent.

Habitat: *Polycheria osborni* was first described from Puget Sound, Washington, where eight specimens, all females bearing ova, were found "in nests in *Amaræcium.*" In Monterey Bay, California, the species is fairly common in the rocky tide pools, where it lives in cavities of the compound ascidian *Amaroucium.* The surface temperature in the tide pools usually is somewhere between 50° and 55° F.; only seldom 48° or 49° and 57° or 58° are recorded.

Remarks: The specific allocation of this form is somewhat uncertain, since Calman's (1898, p. 268) description if *Polycheria osborni* (recorded from Puget Sound, Washington) is quite superficial and incomplete. However, Calman's and our specimens undoubtedly show similarities sufficient to make their identification at least highly probable. The only differences worth notice are as follows. According to Calman's figures, (1) the palp of the first maxilla has 7, instead of 5, bristles (only a few of the Monterey Bay specimens had 6 bristles); (2) the distal joint (finger) of the first gnathopod is somewhat longer, relatively.

Stebbing (1906, p. 520) considers *Polycheria osborni* identical with *P. tenuipes* Haswell (1879), *P. obtusa* G. M. Thomson (1882), and possibly also with *P. brevicornis* Haswell (1879), three forms described from Australia and New Zealand. We have not judged it advisable to follow this identification on account of the very incomplete descriptions and remoteness of habitats of these forms.

In order to establish the range of variation, ten specimens were carefully examined. All these specimens were from the same locality; and several of them were taken in the same tide pool. As will be seen from the description given above, nearly all the external characters exhibit a more or less pronounced variability. In spite of this, there can be no reasonable doubt about all the specimens belonging to the same species.

This variability is very significant, since it demonstrates the necessity of a more careful morphological analysis of the sys-

tematic units than has hitherto been practiced by most of the investigators of this group. Most of the specific descriptions of the Amphipods are very short, and little or no attention has been paid to the variability. If *Polycheria osborni* can exhibit such plasticity at a locality where the physico-chemical conditions are unusually constant, an even greater variability may characterize the species at localities of more varied conditions, and, especially, within its entire range of distribution. Of course, it is possible that this species is unusually variable, but a high degree of variability may characterize many other species of the group. In other words, many forms, now accepted as valid species, may be founded on modifications.

All the specimens carefully examined (ten) were females; and no males were found among 30-40 individuals which were studied in a more superficial manner. It should be observed that eight specimens recorded by Calman (1898) also were females.

Some of the specimens on which our description is founded, together with some of the *Amaroucium* colonies, have been deposited with the institution that has published this report.

Habits and behavior of Polycheria osborni

Polycheria osborni is found in sheltered parts of rocky tide pools, where it lives in cavities or burrows which it makes in the tough, semitranslucent tests of the various species of the genus *Amaroucium,* a composite ascidian. It appears to prefer places which are not exposed to the air even during the lowest tides, but this choice is by no means universal. Frequently specimens are found above the water line; but in this case the habitat usually seems to be moist and cool crevices, the openings of which are more or less covered by a heavy, overhanging growth of algae. The animal does not occur on the lower side of loose rocks but always on the exposed side which is washed by moving water. This preference is inti-

mately connected with the peculiar mode of feeding characteristic of this species. The pale ascidian colonies in which many of the zooids are dead appear to be preferred. Sometimes only one or a few specimens are found in a fairly large group of ascidians; sometimes the amphipods are so numerous that they actually crowd each other. This crowding is probably not due to any tendency to form colonies but simply to the fact that the young tend to make their burrows as soon as they have left their mother. The spreading of the species, to a large extent, appears to be carried out by the currents caused by waves and tides. The number of specimens in a colony can readily be counted. Each individual shows up, through the semitranslucent test, as a pinkish body somewhat larger than the ascidian zooids.

When in its burrow, *Polycheria* lies on its back. The burrow fairly closely conforms to the general shape of the body and usually is but slightly larger than this (fig. 26). Sometimes specimens are found that are not quite covered; in these cases the cavities are not yet finished. When completed, the burrow is deep enough to house the entire animal; as a matter of fact, its depth is subequal to the depth of the body proper of the animal and the length of the pereiopods. The edges of the burrow are held firmly by the distal fingers of the first, second, fourth and fifth pereiopods, and it is by the movements of these legs that the burrow is opened and closed. When open, the aperture of the burrow is irregularly elliptical, about 2.5 – 3.0 times longer than wide and about as long as the animal when this is in its natural, somewhat curled position. When closed, the long edges of the ellipse are pressed together, forming as it were, a slightly zigzag seam, the stitches of which are represented by the eight distal fingers of the four pairs of pereiopods noted above. The length of the seam about equals the length of the aperture of the open burrow. The zigzag shape, of course, is due to the pull of the legs. When the burrow is closed, the fingers of the pereio-

pods usually are the only parts of the animal to be seen and even they may be out of sight. Sometimes, however, the antennæ are held out even in this condition. While the first, second, fourth, and fifth pereiopods are directed more or less upwards when the animals lies on its back in the burrow, the third pair is directed slantingly downwards (fig. 26). Its function has not been established with certainty, but it appears to anchor the animal to the bottom of the burrow. In any case, the structure of its distal end indicates that it has a function somewhat similar to the one of the remaining pereiopods.

While the animal lies undisturbed in its burrow, the latter is kept open and the three pairs of pleopods are intermittingly beating back and forth, thus causing a rather strong current of water, the main direction of which is backwards. It was observed that the fanning of the pleopods ceases for a short time when the animal is disturbed, and that it becomes somewhat more rapid and intense when the water is slightly stale. A somewhat more developed staleness and a fairly moderate rise of temperature soon causes the death of the animal. The current moves from the head end and the sides of the burrow down to the middle portion of the ventral side of the animals where the gills are located. From there it continues backwards to the abdomen whose upward direction causes it to shoot almost straight up. The rising current, of course, also sucks in some water from behind, but this contribution is insignificant. The course of the current can readily be established by pouring carmine suspended in sea water over the burrow. The function of the current appears to be primarily respiratory. At any rate, most of the water seems to be drawn in from the sides of the burrow and does not pass through the antennæ. However, at least some of the current passes through these appendages, and there can hardly be any doubt that it partly serves as a carrier of food.

As far as we have been able to decide, the food consists almost exclusively of detritus and small animals and plants.

Diatoms are frequently found on the mouth parts and in the stomach. *Polycheria* does not go out hunting for food, as do most of the other members of the amphipod group. Instead, it lies in its burrow waiting for the food to come its way, carried there by the currents produced either by the animal itself or by waves and tides. The first and second antennæ, which are quite long and furnished with numerous rather long hairs, are carried ventrally (i. e. upwards) somewhat laterally, and slightly anterior to the head (fig. 26). For long periods they are kept perfectly still. Then, all of a sudden, they are quickly bent down towards the gnathopods and maxillipeds which seize them and carry out combing movements. The structure of these appendages is interesting to study from the viewpoint of this function. The bending probably takes place whenever edible material comes in contact with the antennæ. The sensory hairs on the first antennæ undoubtedly help in the chemical analysis of the material caught. After the food particles are combed off by the gnathopods and the maxillipeds, they are transferred to the mandibles and maxillæ which seize them and begin mastication and the transportation to the mouth. As will be seen from the description, the mandibles and the first maxillae are quite strong masticatory organs. During these processes the gnathopods are pressed over the mouth parts. After their completion, the gnathopods are raised and spread to make ready to receive the antennæ again. However, they do not remain idle when there is no food to be handled but are always ready to be used for cleaning other parts of the body.

When undisturbed, the animal usually remains in the same position in its burrow; but sometimes, for some unknown reason, it turns around so that its head comes to be where its posterior end was. If exposed to a minor mechanical stimulus, for instance the light prodding with a needle near its burrow, it closes the aperture of the burrow in the manner described above and keeps perfectly still. Soon, however, its pleopods

begin to fan and in a little while its antennæ may be extended. On the other hand, a more or less decided rise in the temperature of the water, a strong, mechanical stimulus, or a chemical stimulus, such as oxygen deficiency or the adding of a harmful compound to the water, causes the animal to desert its haunt. After a rather short swimming dash, it begins to crawl around on the substratum. When swimming, it is propelled exclusively by the pleopods; and it moves anteriorly with great speed with the dorsal side down. While swimming, the animal shows a fairly strong positive heliotropism, a characteristic not evident in crawling. The positive heliotropism is probably correlated with the preference of this species for the exposed side of the rocks in the tide pool. In walking or crawling, the animal moves sluggishly in the anterior direction occupying the same position as in the burrow, i. e., with its ventral side up. It uses its first, second, third, and fourth pereiopods which are held dorsally (i. e., downwards). The fifth pereiopod is held ventrally (i. e., upwards) in walking. Only occasionally does it help in locomotion. Its main function appears to be to help the first, second, and fourth pereiopods in opening and closing the aperture of the burrow. The peculiar habit of always keeping the ventral side up is so thoroughly established in this species that even the young crawl on their backs when they leave the brood pouch of the mother. The walking is always slow, and the animal feels its way by gently touching the objects ahead with its antennæ.

Contrary to most of the other members of the amphipod group, *Polycheria* is exceedingly sluggish, a characteristic presumably connected with the habit of living in a burrow. A specimen may settle down on the rounded tip of an *Amaroucium* colony, apparently in a very uncomfortable position, get a firm hold of the test, and then remain for several hours without exhibiting any appreciable movements, except the intermittent flipping of the pleopods. Indeed, even if many

specimens are kept in a quiet aquarium, one may watch them for hours without anything happening.

When hunting for a location for a new burrow, the animal is distinctly selective. If placed on a soft sponge or on an ascidian other than *Amaroucium,* it does not settle down but crawls around restlessly and finally swims away. If kept in an aquarium with no *Amaroucium,* it scouts around until it finally dies, apparently from exhaustion. It may be mentioned in this connection that the species appears not to be very resistant. It is difficult to keep alive in an aquarium for more than a couple of days and usually dies before most of the other animals.

In making its burrow, the animal does not dig in the strict sense of this word. It lies on its back, grasps the surface of the ascidian test with its first, second, fourth, and fifth pereiopods and then begins to pull slowly. The tough test slowly yields. In this way the back of the animal is gradually pushed into the test; and finally it is so deep down that the edges of the cavity thus formed can be pulled over the animal. This operation required, when observed in an aquarium, several hours. This mode of making the burrow is probably the reason why the *Amaroucium* colonies with many dead zooids are preferred; in these colonies the tests are presumably softer and thus yield more readily to the pull. However, *Polycheria* is fully capable of making its burrow in young and vigorous colonies as well. The cavities of the dead zooids have not been observed to be appropriated by the full grown *Polycheria.* On the other hand, the young specimens, recently out from the brood pouch, evidently prefer any small depression they can find.

The females carry eggs and young in their brood pouch throughout the summer months. In some females as many as 70-80 eggs were counted. The eggs hatch at different times, and the young are forced out of the brood pouch by the mother who for this purpose uses her gnathopods. The young leave through the anterior opening of the brood pouch,

and while the mother is trying to force them out they cling tenaciously to the hairs of the mother evidently reluctant to leave their shelter. The number of young forced out each time varies from one to four. At this stage the young measure about 0.3 – 0.4 mm. in length, exclusive of the antennæ. Immediately after having been removed from the marsupial pouch, the young begin to hunt around for a lodging place. As noted above, they usually do not select an even place for their first burrow but prefer a small depression which they turn into a burrow in the same manner as do the larger specimens. They appear frequently to settle near the mother. This is indicated by the fact that one often finds a large specimen surrounded by the burrow of many young ones. On the other hand, they are probably often washed away by the currents of waves before they have a sufficiently strong hold. In this manner, as noted previously, the species is dispersed.

The living together of *Polycheria* and *Amaroucium* can probably not be regarded as a case of commensalism. As far as we have been able to observe, the ascidian does not draw any benefit whatsoever; it simply furnishes *Polycheria* with a home. At the same time, it is also doubtful that *Polycheria* harms its host to an appreciable extent.

As will be seen from the above account, the ecology of *Polycheria osborni* is quite simple, as far as we have been able to establish. At the same time, it exhibits some peculiar and interesting features, the most outstanding among which are its habit always to be oriented with its ventral side up, a character presumably acquired in connection with its habit of living in a burrow and its mode of feeding. *Its orientation and mode of feeding presumably are the same as in the ancestral forms of the Cirripedia,* and the species may serve as an analogous example to illustrate the origin of this group. However, while in the Cirripedia this mode of living led to profound morphological changes in *Polycheria* only slight deviations from the related genera resulted.

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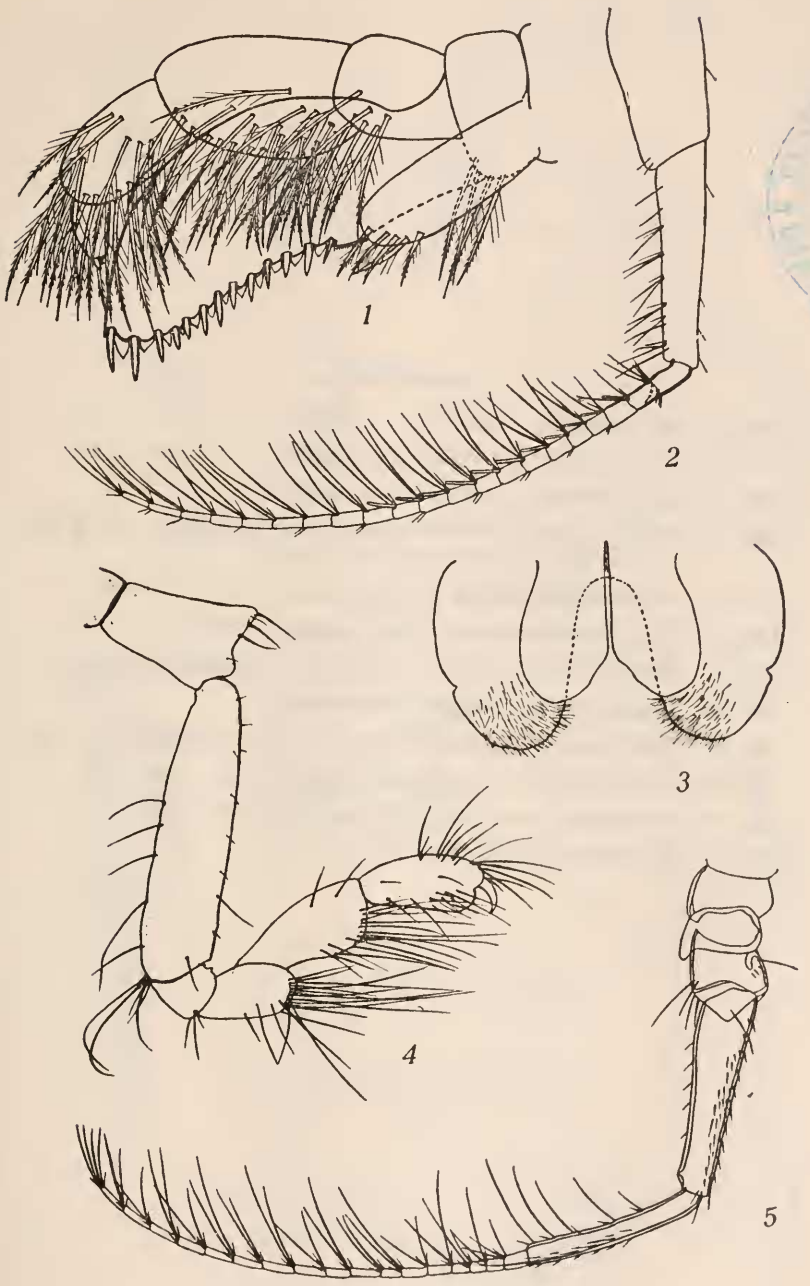
Fig. 1. Left maxilliped from ventral side. Palp covered by second endite. Next to distal joint seen in tilted position and so its characteristic subtriangular shape is not brought out. Magnification unknown.

Fig. 2. First antenna. ×53.

Fig. 3. Labium, seen from dorsal side. ×120.

Fig. 4. Left second gnathopod. ×67.

Fig. 5. Second antenna. ×53.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Polycheria osborni.

Fig. 6. Left mandible. Magnification unknown.

Fig. 7. Two distal joints of right first gnathopod, from inside. ×217.

Fig. 8. Right mandible. Magnification unknown.

Fig. 9. Two distal joints of left second gnathopod, from inside. Distal joint with fine, short hairs all over. ×217.

Fig. 10. Two distal joints of left first pereiopod, from inside. ×150.

Fig. 11. Gill and marsupial plate of first pereiopod. ×33.

Fig. 12. Two distal joints of palp of maxilliped. Magnification unknown.

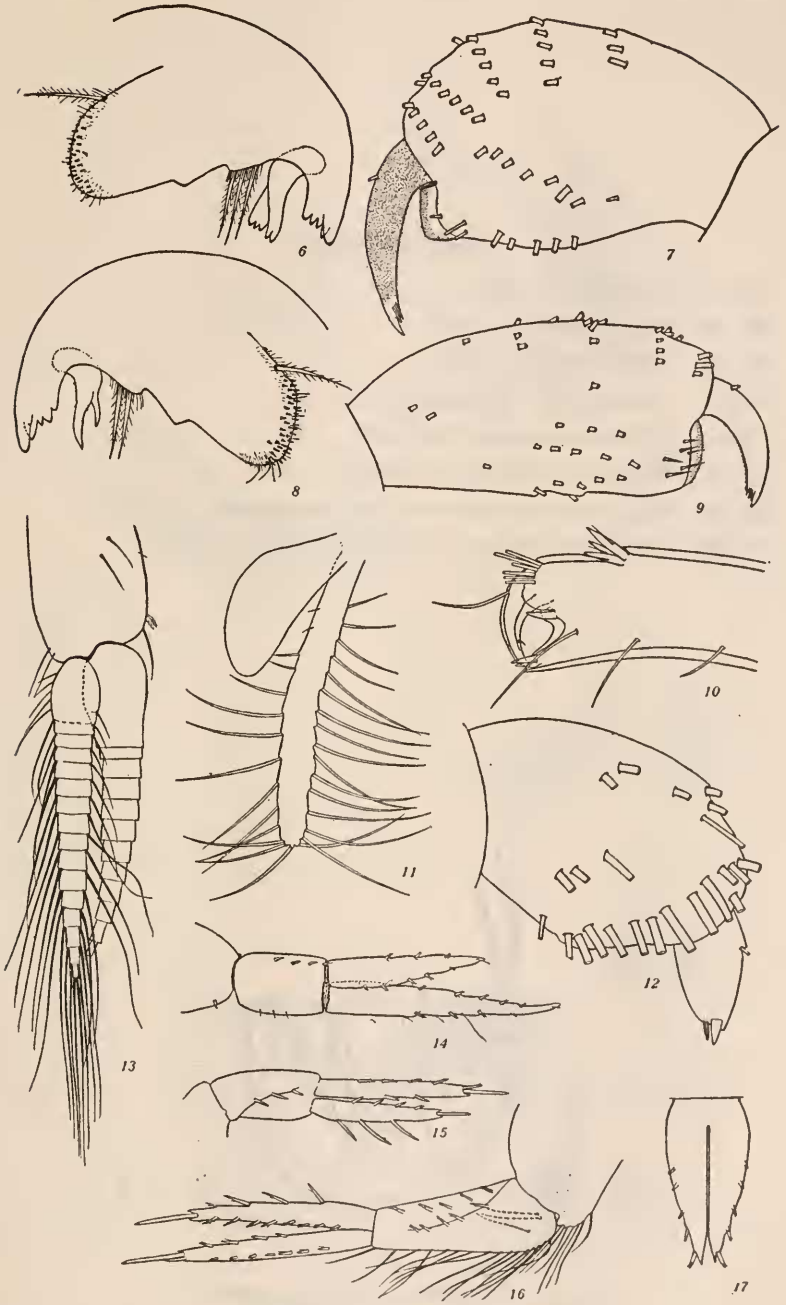
Fig. 13. Second pleopod. Magnification unknown.

Fig. 14. Third uropod, slightly tilted, from dorsal side; lateral side up. ×60.

Fig. 15. Second uropod, from dorsal side; exopodite up. ×60.

Fig. 16. First uropod, from dorsal side; exopodite down. ×60.

Fig. 17. Telson, from ventral side. ×60.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Polycheria osborni.

Fig. 18. First maxilla. ×290.

Fig. 19. Second maxilla. ×290.

Fig. 20. Third pereiopod. ×40.

Fig. 21. Sensory spine. Magnification unknown.

Fig. 22. Left first gnathopod, from inside. ×72.

Fig. 23. Right first pereiopod, from inside. ×40.

Fig. 24. Head, with bases of first antennæ, from above. ×15.

Fig. 25. Fifth pereiopod, from inside. ×40.

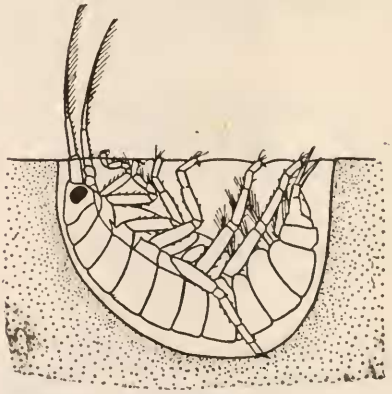

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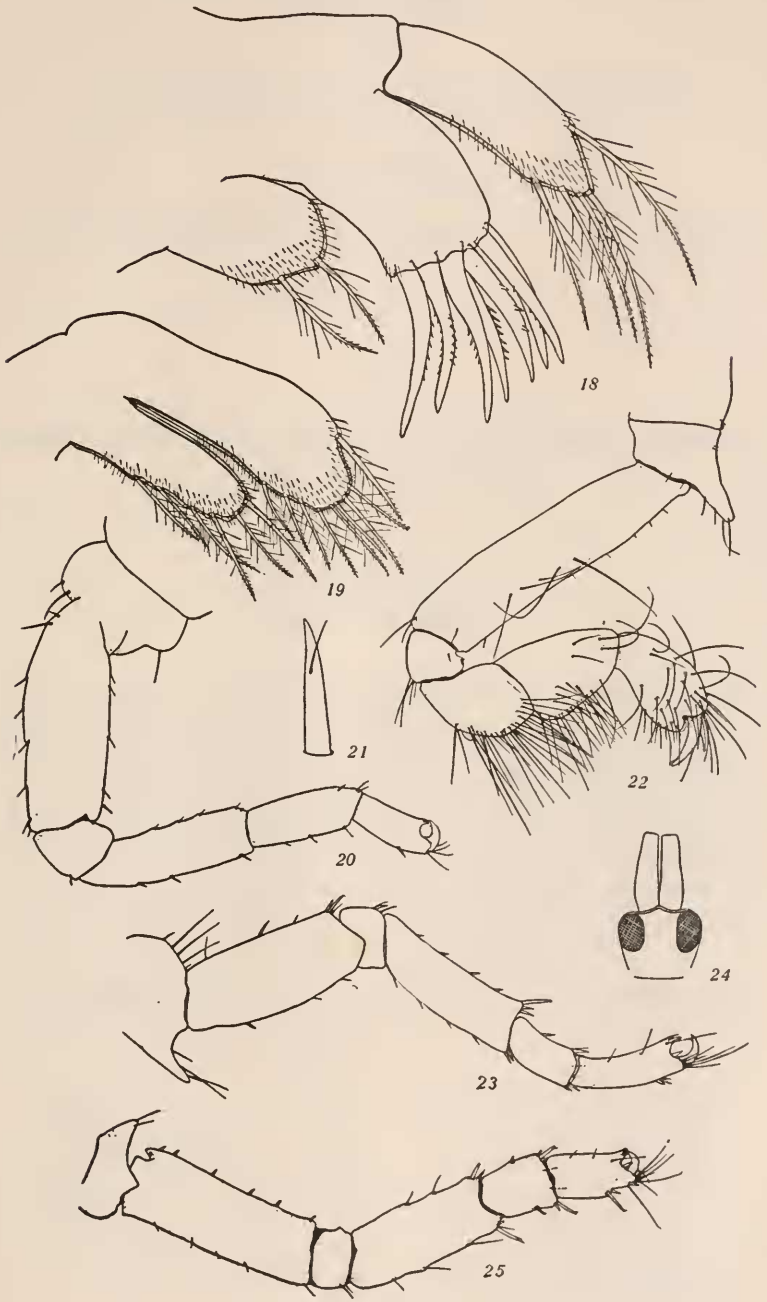
Fig. 26. *Polycheria osborni* in its burrow.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